# PATENT COOPERATION TREATY

# PCT



# INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

| Applicant's or agent's file reference<br>P/63965/GPTX18 | **FOR FURTHER ACTION** | See Form PCT/IPEA/416 |
|---|---|---|
| International application No.<br>PCT/EP2005/051061 | International filing date *(day/month/year)*<br>09.03.2005 | Priority date *(day/month/year)*<br>09.03.2004 |
| International Patent Classification (IPC) or national classification and IPC<br>INV. H04B10/18 | | |
| Applicant<br>MARCONI COMMUNICATIONS SPA et al. | | |

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 5 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. ☒ *sent to the applicant and to the International Bureau)* a total of 6 sheets, as follows:
      ☒ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
   b. ☐ *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in electronic form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).

4. This report contains indications relating to the following items:

| | | |
|---|---|---|
| ☒ | Box No. I | Basis of the report |
| ☐ | Box No. II | Priority |
| ☐ | Box No. III | Non-establishment of opinion with regard to novelty, inventive step and industrial applicability |
| ☐ | Box No. IV | Lack of unity of invention |
| ☒ | Box No. V | Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement |
| ☐ | Box No. VI | Certain documents cited |
| ☐ | Box No. VII | Certain defects in the international application |
| ☐ | Box No. VIII | Certain observations on the international application |

| Date of submission of the demand | Date of completion of this report |
|---|---|
| 05.12.2005 | 01.08.2006 |
| Name and mailing address of the international preliminary examining authority:<br>European Patent Office - P.B. 5818 Patentlaan 2<br>NL-2280 HV Rijswijk - Pays Bas<br>Tel. +31 70 340 - 2040 Tx: 31 651 epo nl<br>Fax: +31 70 340 - 3016 | Authorized officer<br>Vaquero, R<br>Telephone No. +31 70 340-4862 |

# INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/EP2005/051061

## Box No. I Basis of the report

1. With regard to the **language**, this report is based on

   ☒ the international application in the language in which it was filed

   ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of:
   - ☐ international search (under Rules 12.3(a) and 23.1(b))
   - ☐ publication of the international application (under Rule 12.4(a))
   - ☐ international preliminary examination (under Rules 55.2(a) and/or 55.3(a))

2. With regard to the **elements*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

**Description, Pages**

| | |
|---|---|
| 1, 4-18 | as originally filed |
| 2, 3 | received on 05.12.2005 with letter of 01.12.2005 |

**Claims, Numbers**

| | |
|---|---|
| 3-12, 16-26 | as originally filed |
| 1, 2, 13-15, 27, 28 | received on 05.12.2005 with letter of 01.12.2005 |

**Drawings, Sheets**

| | |
|---|---|
| 1/3-3/3 | as originally filed |

☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing

3. ☐ The amendments have resulted in the cancellation of:
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

* *If item 4 applies, some or all of these sheets may be marked "superseded."*

**Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

| | | | |
|---|---|---|---|
| Novelty (N) | Yes: | Claims | |
| | No: | Claims | 1-28 |
| Inventive step (IS) | Yes: | Claims | |
| | No: | Claims | 1-28 |
| Industrial applicability (IA) | Yes: | Claims | 1-28 |
| | No: | Claims | |

2. Citations and explanations (Rule 70.7):

**see separate sheet**

Reference is made to the following documents:

D1 : EP 1 164 724 A (LUCENT TECHNOLOGIES INC) 19 December 2001 (2001-12-19)

D2 : US 6 538 787 B1 (KOGELNIK HERWIG ET AL) 25 March 2003 (2003-03-25)

D3 : VASSALLO C: "PMD pulse deformation" ELECTRONICS LETTERS, IEE STEVENAGE, GB, vol. 31, no. 18, 31 August 1995 (1995-08-31), pages 1597-1598, XP006003355 ISSN: 0013-5194

1 The PCT application still fails to meet the requirements of Articles 33 PCT, and the same arguments given in the previous Written Opinion dated 09/03/2005 are maintained.

2 INDEPENDENT CLAIMS

2.1 Claim 1

The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claim 1 is not new in the sense of Article 33(2) PCT.
Document D1 discloses (the references in parentheses applying to this document): a transmission system comprising two optical signals produced by two transmitters transmitted over the same fibre at the same wavelength but with orthogonal states of polarisation (p.3, l.8-10) and a receiving apparatus capable of filtering the two components with orthogonal polarisation of the signal received (p.3, l. 11-18) in accordance with a transfer matrix $H(\omega)$ controlled dynamically on the basis of the output signals in such a manner as to approximate reverse transfer matrix of the fibre in the region of the spectrum occupied by the signal (p.4, l.53-55) so as to compensate for the polarisation mode dispersion and the polarisation rotation introduced by the fibre while eliminating distortion and mutual interference effects for both the signals and obtaining at output an approximate repetition of the two signals transmitted (p.4, l.23-35).

Although the use of two transmitters is not explicitly disclosed in document D1, the use of two transmitters to generate two optical signals is **obvious**, and therefore claim 1 cannot be considered as novel. Moreover, it cannot be considered as involving an inventive step in the sense of Article 33(1) and (3) PCT.

For the sake of completeness it is also pointed out that the subject-matter of claim 1 is also disclosed in documents D2 (c.2, l. 56- c.4, l.10, c.4, l.65- c.5, l.3, c.7, l.1-8), and document D3.

2.2 Claims 14 and 27

The same reasoning applies, mutatis mutandis, to the subject-matter of the corresponding independent claims 14, 27.

3 DEPENDENT CLAIMS 2-13, 15-26, 28

Dependent claims 2-13, 15-26, 28 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty and/or inventive step (Article 33(2) and (3) PCT).

varying rotation to its state of polarization. As a result the state of polarization of the received optical signal is subject to random time-varying rotation. Although this phenomenon will not affect the orthogonality of the two polarization multiplexed signals it will affect the orientation with the orthogonal states of polarization are presented to the receiver thus making their separation impossible without an appropriate dynamic polarization tracking technique.

Moreover, in the case of high-speed symbol transmission systems, Polarization Mode Dispersion (PMD) will widen, distort and depolarize the transmitted pulses and cause considerable deterioration in the quality of the received signal. PMD can also give rise to mutual interference and mixing of the two orthogonal polarization signals.

The present invention arose in an endeavour to at least in part remedy the above mentioned shortcomings and provides a system that allows simultaneous PMD compensation and demultiplexing of polarization multiplexed signals.

In accordance with a first aspect of the invention there is provided a transmission system comprising two optical signals produced by two transmitters and transmitted over the same fibre at the same wavelength but with orthogonal polarization and a receiving apparatus capable of filtering the two components with orthogonal polarization of the signal received in accordance with a transfer matrix which is controlled dynamically on the basis of the output signals in such a manner as to approximate the reverse transfer matrix of the fibre in the region of the spectrum occupied by the signal so as to compensate for the PMD and the polarization rotation introduced by the fibre and eliminating distortion and mutual interference effects for

both the signals and obtaining at output an approximate repetition of the two signals transmitted.

In accordance with a second aspect of the invention there is provided a transmission method comprising two optical signals transmitted over the same fibre at the same wavelength but with orthogonal polarization, said two signals being produced by two transmitters, wherein at the receiving side filtering the two components with orthogonal polarization of the signal received according to a transfer matrix and dynamically controlling the transfer matrix on the basis of the signals output in such a manner as to approximate the reverse transfer matrix of the fibre in the region of the spectrum occupied by the signal so as to compensate for the PMD and the polarization rotation introduced by the fibre while eliminating distortion and mutual interference effects for both the signals and obtaining at output an approximate repetition of the two signals transmitted.

In accordance with a further aspect of the invention there is provided an apparatus for receiving an polarization multiplexed optical signal transmitted over a fibre and made up of two polarization multiplexed signals, said two signals being produced by two transmitters, and to perform simultaneous compensation of the polarization mode dispersion (PMD) and demultiplexing of the two signals, wherein the apparatus comprising means which filter the two orthogonal polarization components of the signal received according to a transfer matrix which is controlled dynamically on the basis of the signals output in such a manner as to approximate the reverse transfer matrix of the fibre in the region of the spectrum occupied by the signal so as to compensate for the PMD and the polarization rotation introduced by the fibre while

CLAIMS

1. Transmission system (10) comprising two optical signals ($z_1$, $z_2$) produced by two transmitters (13) and transmitted over the same fibre (15) at the same wavelength but with orthogonal states of polarization and a receiving apparatus (10) capable of filtering the two components with orthogonal polarization of the signal received in accordance with a transfer matrix $H(\omega)$ controlled dynamically on the basis of the output signals ($s_1$,$s_2$) in such a manner as to approximate the reverse transfer matrix of the fibre in the region of the spectrum occupied by the signal so as to compensate for the polarization mode dispersion and the polarization rotation introduced by the fibre while eliminating distortion and mutual interference effects for both the signals and obtaining at output an approximate repetition of the two signals transmitted.

2. System in accordance with claim 1 characterized in that the transfer matrix $H(\omega)$ is:

$$H(\omega) = e^{-j\frac{N}{2}\omega\tau}\begin{pmatrix} C(\omega) & D(\omega) \\ -D^*(\omega) & C^*(\omega) \end{pmatrix} \quad (1)$$

with the two functions $C(\omega)$ and $D(\omega)$ given by:

$$C(\omega) = \sum_{k=0}^{N} c_k e^{-j(k-N/2)\omega\tau} \quad (2)$$

$$D(\omega) = \sum_{k=0}^{N} d_k e^{-j(k-N/2)\omega\tau} \quad (3)$$

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$$H(\omega) = e^{-j\frac{N}{2}\omega\tau}\begin{pmatrix} C(\omega) & D(\omega) \\ -D^*(\omega) & C^*(\omega) \end{pmatrix} \quad (1)$$

$$|C(\omega)|^2 + |D(\omega)|^2 = 1 \quad (4)$$

with the two functions $C(\omega)$ and $D(\omega)$ represented by their Fourier series expansion ($N$+1 terms)

$$C(\omega) = \sum_{k=0}^{N} c_k e^{-j(k-N/2)\omega\tau} \quad (2)$$

$$D(\omega) = \sum_{k=0}^{N} d_k e^{-j(k-N/2)\omega\tau} \quad (3)$$

where $c_k$ and $d_k$ are complex coefficients linked unlinearly to the real control parameters of the device.

13. System in accordance with claim 3 characterized in that the demultiplexing device (17) comprises a cascade of polarization controllers (PC) and polarization maintaining fibres (PMF).

14. Apparatus (10) for receiving an polarization multiplexed optical signal which has been transmitted over a fibre (15) and is made up of two polarization multiplexed signals ($z_1$, $z_2$), said two signals being produced by two transmitters (13), and for

performing simultaneous compensation of polarization mode dispersion and demultiplexing of the two signals, the apparatus comprising means (17) which filter the two components with orthogonal polarization of the received signal in accordance with a transfer matrix $H(\omega)$ controlled dynamically on the basis of the output signals so as to approximate the reverse transfer matrix of the fibre in the region of the spectrum occupied by the signal so as to compensate for the polarization mode dispersion and the polarization rotation introduced by the fibre while eliminating effects of distortion and mutual interference for both the signals and obtaining at output an approximate repetition of the two transmitted signals.

15. Apparatus in accordance with claim 14 characterized in that the transfer matrix $H(\omega)$ is:

$$H(\omega) = e^{-j\frac{N}{2}\omega\tau}\begin{pmatrix} C(\omega) & D(\omega) \\ -D^*(\omega) & C^*(\omega) \end{pmatrix} \quad (1)$$

with the two functions $C(\omega)$ and $D(\omega)$ represented by their Fourier series expansion ($N$+1 terms):

$$C(\omega) = \sum_{k=0}^{N} c_k e^{-j(k-N/2)\omega\tau} \quad (2)$$

$$D(\omega) = \sum_{k=0}^{N} d_k e^{-j(k-N/2)\omega\tau} \quad (3)$$

with

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27. Transmission method comprising two optical signals transmitted over the same fibre at the same wavelength but with orthogonal polarization, said two signals being produced by two transmitters, and that at the receiving side filters the two components with orthogonal polarization of the signal received in accordance with a transfer matrix $H(\omega)$ controlled dynamically on the basis of the signals output so as to approximate the reverse transfer matrix of the fibre in the region of the spectrum occupied by the signal so as to compensate for the polarization mode dispersion and the polarization rotation introduced by the fibre while eliminating distortion and mutual interference effects for both signals and obtaining at output an approximate repetition of the two transmitted signals.

28. Method in accordance with claim 27 characterized in that the transfer matrix $H(\omega)$ is:

$$H(\omega) = e^{-j\frac{N}{2}\omega\tau}\begin{pmatrix} C(\omega) & D(\omega) \\ -D^*(\omega) & C^*(\omega) \end{pmatrix} \quad (1)$$

with the two functions $C(\omega)$ and $D(\omega)$ represented by their Fourier series expansion ($N$+1 terms):

$$C(\omega) = \sum_{k=0}^{N} c_k e^{-j(k-N/2)\omega\tau} \quad (2)$$

$$D(\omega) = \sum_{k=0}^{N} d_k e^{-j(k-N/2)\omega\tau} \quad (3)$$

with